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(54) MICRO-HEATING ELEMENT

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED, INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to micro-heating elements, which are to be understood in this Specification to mean elements in which the heating resistor is not longer than three millimetres.

Such heating elements may be used for heating cathodes for small-size electron tubes such as are used, for example, in mobile radio-telephones and transistorized television sets.

Heating elements of metal have the disadvantage that their resistivity is not very high so that stable elements of a sufficiently high resistance can only be obtained with difficulty, if at all.

Semiconductor materials have a higher resistivity. For the purpose referred to above, they must however be able to withstand high temperatures and must also be chemically fairly inert. This desired combination of properties is found in silicon carbide.

Such micro-heating elements could be obtained by grinding down silicon carbide crystals, but these are comparatively expensive and difficult to grind to size. If considerably cheaper silicon carbide plates obtained by sintering are used, then difficulties are encountered in manufacturing large quantities of elements of uniform resistivity. Furthermore, sintered elements of small dimensions are very weak mechanically.

The invention provides a micro-heating element, comprising a silicon carbide single-crystal whisker less than 3 mm long and provided with electric supply conductors thereto.

Such a "whisker", i.e. a grown single-crystal hair-like filament, may have a circular, polygonal, or other cross-section. It may be strip-shaped.

The whiskers may, for example, be reproducibly manufactured by depositing them on the walls of a cavity present in a silicon carbide body by recrystallisation and/or condensation of silicon carbide in an inert gas atmosphere containing lanthanum at temperatures above 2000°C, preferably between 2200° C and 2600°C. Such a method is described and claimed in Patent Specification 1,208,001.

In another method the whisker crystals may be grown on a substrate from a gas phase containing silicon and carbon by providing finely-divided iron locally on the substrate and heating it to a temperature above 1200°C, during which process silicon and carbon are absorbed from the gas phase by the iron, and silicon carbide crystals are deposited on the substrate. Such a method is described and claimed in co-pending Patent Application 56404/67 Serial No. 1213156.

As is well-known it is important that heating elements should have a positive temperature coefficient of resistance. This may in the present example be achieved by carrying out the whisker crystallisation in an atmosphere containing a suitable additive, such as nitrogen, which will be incorporated in the whiskers.

After obtaining whiskers of the desired thickness and resistivity in the manner described, they may be divided along their length direction to provide a large number of heating elements.

In order that the invention may be readily carried into effect an embodiment will now be described in detail, by way of example with reference to the accompanying diagrammatic drawing, which shows a cathode having a heating element according to the invention.

A silicon carbide crystal containing an additive such as 10^{17} atoms per cm^3 of nitrogen

[Price 25p]

to make its temperature coefficient of resistance positive is indicated by 1. Current supply wires 2 may be provided in a simple manner by connecting the ends of the whisker 1 to wires of a refractory metal, for example by means of solder 3 consisting of a gold alloy containing 5% by weight of tantalum. Such joints can withstand temperatures up to 1300° C. Suitable soldering materials for higher temperatures are, for example, nickel containtaing 5% by weight of molybdenum (up to 1500°C) or of tungsten (up to 1800°C).

When using the heating element 1 in a cathode of an electron tube, it is important that the heating circuit should be electrically separated from the cathode. In the embodiment shown this is achieved in a simple manner by providing an insulating layer 4 on the crystal. This layer can withstand high temperatures and may be made, for example, of an oxide or nitride of aluminium or silicon. On this layer is deposited a metal layer which carries a mass 5 of a thermionic emitter, for example barium oxide containing an addition of calcium.

WHAT WE CLAIM IS:—

1. A micro-heating element, comprising a silicon carbide single-crystal whisker less than 3 mm long and provided with electric current supply conductors thereto.

2. An element as claimed in Claim 1, wherein the silicon carbide contains an additive which makes its temperature coefficient of resistance positive.

3. An element as claimed in Claim 2 wherein the additive comprises nitrogen.

4. An indirectly heated cathode including a micro-heating element, substantially as herein described with reference to the accompanying drawing.

5. An indirectly heated cathode provided with a heating element as claimed in any of Claims 1 to 3.

6. An electric discharge tube including a cathode as claimed in Claim 4 or Claim 5.

C. A. CLARK,
Chartered Patent Agent,
Century House,
Shaftesbury Avenue,
London, W.C.2.
Agent for the Applicants.

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1222887 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*